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Transfusion Errors: Causes and Effects

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HUMAN error is an ubiquitous accompaniment of human activity. In the vast majority of daily circumstances the results of error are, at most, annoying or inconvenient. Some classic examples are leaving car keys in the ignition or wearing mismatched socks. However, in such error-critical fields as aviation, nuclear power, and medicine, even though the vast majority of errors are benign and contained, they have a greater potential for catastrophic results. It has been estimated that as many as one medication error per patient per day occurs in hospitals in the United States.[1] Most of these errors do not affect patients or lengthen the duration of their hospitalization, although some do have serious, and even fatal effects. In transfusion medicine, there is a similar preponderance of "benign" error. However, because of preformed antibodies in the ABO system, and their potential for an acute hemolytic transfusion reaction, an active error such as misidentification of the patient or specimen has a magnified potential for harm because of its possible combination with the pervasive potential of blood group incompatibility. The term latent error is used in contrast to the term active error, the effects of which are immediately appreciated.[2] The latent error may exist within the system for varying periods, typically dormant and unnoticed until, when combined with another factor, such as an active error, it causes an accident. Active errors are most often committed by line personnel. Latent errors reflect the environment in which an error occurs. They are characteristically managerial in origin and are often caused by policy decisions or system design.

Recognition that incompatible blood can cause a serious or even fatal reaction dates to the early days of transfusion. In fact, the earliest report of a transfusion reaction is attributed to Denys in 1667,[3] long before identification of blood groups enabled the procedure to be performed on a routine basis. In 1942, Kilduffe and DeBakey published data collating the collective experience of several investigators over the 24-year period of 1917 to 1941, citing a risk for hemolytic transfusion reaction of 1 in 541 transfusions (80/43,284), and a mortality rate for transfusion reaction of 58%, leading to a risk of death from transfusion of 1 in 935 transfusions.[4] In 1943, Wiener reported a death rate from transfusion of 1 in 915.[3] In 1951, Muirhead reported a mortality rate from acute hemolytic transfusion reaction (AHTR) of 36% (10 of 28 patients suffering reactions from mismatched blood died).[5]

A detailed study of transfusion reactions from 1952 to 1957 at a large urban hospital in New York City was published by Binder et al.[6] The investigators reported that 30 patients received the wrong blood in a total of 81,392 transfusions (1/2, 713 units). Seven patients died (1/11, 625), although in two cases, the death was attributed primarily tothe patient's existing condition, with the transfusion reaction only a contributing factor. Another patient survived, but delivered stillborn twins after a severe reaction to an incompatible transfusion. Symptoms were observed with transfusion of as little as 25 to 100 mL. The rate of AHTR was 1/4,520 units, with a mortality rate of 39%.[6]

Of the 30 patients identified in Binder et al's study, 26 received ABO-incompatible whole blood (the plasma in 18 contained incompatible red blood cells, whereas 8 contained A or B antibodies against the recipients' red blood cells). Two cases involved incompatibility regarding the D antigen (O-positive blood to an O-negative recipient in both cases), whereas incompatibility was attributed to other antigens (not identified) in two others. Of the 30 patients 10 exhibited no hemoglobinemia or hemoglobinuria despite proof of incompatibility (7 had some reaction, whereas 3 had none); 6 had hemoglobinemia and hemoglobinuria alone; 3 had oliguria of less than 48 hours duration; 6 had oliguria of longer than 48 hours duration; and 5 exhibited a hemorrhagic diathesis (all died). The majority of deaths were attributed to

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molytic transfusion reaction at 1/500,000, with two thirds resulting from clerical errors such as the lack of proper identification. A 1988 National Institutes of Health consensus conference cited a 1/100,000 risk of death from transfusion, not counting transfusion-associated acquired immunodeficiency syndrome[13] (this may have included transfusion-associated hepatitis). Barton's 1990 review of noninfectious transfusion reactions cited a 10% mortality rate for AHTR, almost invariably from refractory hypotension, disseminated intravascular coagulation, and/or renal failure.[14] Goldfinger reported that the severity of reaction correlated with the volume of incompatible blood infused.[15]

A 1963 report found that most blood bank errors were clerical in nature.[16] A 1967 British report, after a highly publicized transfusion "catastrophe," advocated increased attention to the potential for clerical error.[17] A large 1966 study of errors associated with collection and processing found an average of one clerical error per 2,000 units processed.[18]

A small 1989 British study identified five ABO errors in 30,456 transfusions, for a rate of 1/6,000 units.[19] The investigators found that compound errors were usually at fault, a combination of active and latent circumstances, such as more than one patient with the same surname on the same hospital floor or in the operating room simultaneously.[19]

RECENT COMPREHENSIVE STUDIES

The US Food and Drug Administration (FDA) mandated reporting of transfusion-associated fatalities in 1975. In 1980, by Memorandum of Understanding, the Health Care Finance Administration agreed to investigate these fatalities in greater depth. The file of such reports, maintained formerly by the Bureau of Biologics and now by the Center for Biologics Evaluation and Research, is open under the Freedom of Information Act. It has been reviewed and analyzed by multiple investigators, including (with date of publication and number of reports studied in parenthesis): Schmidt[20,21] (1980, 69), Honig and Bove[22] (1980, 70), Mythre[12] (1980, 113), Camp and Monaghan[23] (1981, 126), Edinger[24] (1985, 275), and Sazama[25] (1990, 355).

In the most recent and most comprehensive analysis Sazama[25] reviewed 355 reports and studied 256 (99 did not involve transfusion, 68 related to transfusion-associated hepatitis, 3 related to transfusion-associated acquired immunodeficiency syndrome, and 1 report could not be located). AHTR resulting from ABO incompatibility accounted for the majority of reports (51%). The other cases included: acute pulmonary injury (15%), bacterial contamination (10%), delayed hemolysis (10%), damaged product (3%), and graft-versus-host disease (0.4%).[25]

Sazama found 131 cases of ABO incompatibility among the 158 cases of acute hemolysis, with the volume of blood leading to death ranging from 30 mL to 3 units. In 85% of these cases, a group O recipient received incompatible red blood cells, most commonly group A. However, she pointed out that this is likely statistically based on blood group frequencies, because in the event of an error a group O recipient has a 60% chance of receiving an incompatible unit, whereas a group A recipient has only a 9% chance. Nine cases were acute hemolytic reactions involving allo-antibodies to antigens of other blood group systems: 5-K; 1-Jk^b; 1-Fy^a; 1-$Jk^a + Jk^b + Jk3$; and 1-$E + K + P_1$. Delayed acute hemolytic reactions accounted for 26 cases. There were six cases attributed to nonserologic problems, including: 1 was improper deglycerolization of blood for a 1,000-g infant; 3, hemolysis by a blood warmer heating to greater than 40°C; 1, hemolysis caused by adverse temperatures during transportation without adequate packaging; and 1, transfusion with an improper solution (0.5 normal saline).[25]

Among the deaths caused by ABO-incompatible transfusion, Sazama reported that seven involved incompatible plasma or platelets and probably did not relate to error. She estimated the total death rate from red blood cells for all causes to be 0.5 to 1 per 100,000 patients (each receiving approximately 3.5 units of red blood cells). She found one third of all deaths and two thirds of incompatible red blood cell transfusions were attributable to error and were therefore preventable. She estimated that 135 such errors occurred in approximately 100,000,000 transfusions, for a mortality risk of approximately 1/800,000 units.[25]

Sazama also reported that 5 of the 26 hepatitis B deaths resulted from error, with 3 seropositive units labelled properly but released in error and 2 seropositive units labeled as negative. Additionally, of 12 reported donor deaths, 1 related to an O-positive plasma donor who received group A red blood cells from a fellow donor in 1982.[25]

Sazama concluded that errors leading to fatality

approval of policies and procedures relating to the distribution, handling, use, and administration of blood and blood components, but that explicit responsibility is assigned to nursing for administration of blood products.[25]

Mummert and Tourault updated this report and reviewed 150 transfusion-associated fatalities reported to the FDA from 1990 to 1992.[27] They concluded that nearly one third of these fatalities could have been prevented by adherence to proper procedure (interestingly, nearly one third of aviation accidents are caused by a crew member not following established procedure[28]) and reported that proper transfusion of ABO-incompatible blood cells because of error continues to be the primary cause of preventable death. They identified failures in the following areas: (1) the accurate identification of the patient; (2) the recognition of the signs of a transfusion reaction and appropriate action to discontinue the transfusion; (3) the verification that equipment in use was functioning properly before and during use; (4) the training of employees in adherence to standard operating procedures. The investigators reported that failure to follow standard operating procedures in place were a significant problem, and they advocated staff education, training, and monitoring for adherence on an on-going basis.[27]

The investigators in this study also reported that failure to identify a reaction in progress contributed to many of the fatalities. Again, in an analogous way in other error-critical areas such as nuclear power and aviation, minimizing delay in detecting a problem, properly identifying its cause, and implementing corrective actions are recognized as critical issues. The management of error, or of unplanned effects, is an issue of fundamental importance in system design and training, particularly since Three-Mile Island. Although the importance of this has been appreciated in transfusion medicine, its proper emphasis has not been carried through to all critical operational areas. In some cases signs or symptoms were treated, but the transfusion was not identified as the cause and was continued without notification of the blood bank. They reported that in several cases signs such as hemoglobinuria were noted without it being recognized as possibly being caused by a transfusion reaction. In one case, an infant went into shock following receipt of 30 mL of blood. The baby was resuscitated, transfused with more blood, and ultimately died. In this case an unapproved warming device in the operating room warmed the blood to at least 60°C, leading to hemolysis without the knowledge of the blood bank. They also described several cases in which microwave ovens were used to warm blood which led to hemolysis, and stressed that the evaluation of devices before use and the ongoing monitoring of procedures are important.[27]

Mummert and Tourault found that most of the errors occurred outside of the blood bank and were largely in violation of existing operating protocols. They advocated facility comprehensive quality assurance programs to identify inappropriate procedures in the facility and reinforce the purpose and intent of required procedures. They also stressed the importance of the design of systems to prevent and detect errors on an ongoing basis, as well as procedures for equipment validation.[27]

Linden et al studied 104 significant transfusion errors reported in New York State.[11] In 1989 regulations were put in place requiring the reporting of significant errors, accidents, and incidents occurring during the collection, processing, release, or transfusion of blood. This differs from the federal reporting of only mortality data and, in contrast, includes morbidity and even cases in which there was no harm to the patient. This is an important difference because in complex error-critical activities such as transfusion, catastrophic events, although rare in themselves, are often caused by an unfortunate combination of precursor events or errors. These same errors in different circumstances would have been caught or would have had a benign outcome.

Gambino and Mallon have written about the importance of studying this rich database of potential errors.[29] They pointed out the large number of discrepant blood group determinations detected by historical review of donor center records compared with the relatively few detected when units were retested on receipt at a hospital. Discrepancies detected at the donor center on units drawn from repeat donors were not originally considered errors, because the system caught the discrepancies and prevented the release of these units to inventory. It was ultimately appreciated that discrepancies detected by hospital retesting were limited primarily to units from first-time donors. Although recognized as errors, they were relatively rare and did not by themselves afford as useful a resource

To assess the number of undetected errors in their blood bank, Taswell et al[31] deliberately introduced errors into the routine workload, then assessed the detection rate. They studied three areas: office (filing of records), nursing (donor services and blood collection) and laboratory (blood grouping and other testing). Errors introduced included discrepant results, numerical errors, and records inconsistent with previous records. The vast majority of these planted errors were detected, but a significant minority were not. During the first 3 months of the study, 9.5% of errors were not detected by office staff, 18.2% were not detected by nursing, and 9.1% were not detected in the laboratory. This improved overall to 0.7%, 12.8%, and 11.4%, respectively, at the end of the study over a year later (the laboratory failure rate had been as high as 11.5% in months 4 to 6 and 19.5% in months 7 to 9, and decreased thereafter). They also observed an increase in the number of real errors detected, which presumably occurred previously but went unnoticed. In a separate survey reported in the same article, they estimated their error rate in blood collection and processing at 1/500 units (125 errors in 62,590 units), with 81% of errors being clerical and 19% technical.[31] The importance of this study is not limited to the definition of error rates. Taswell et al showed very effectively that by introducing an active element into searching for known errors and providing positive feedback, they significantly increased the effectiveness of trapping errors. His staff not only increased the detection rate of introduced errors, but also increased the detection rate of real, previously undetected errors from 4 in the first 3 months to 73 in the final 3 months of study.[31] This is consistent with Juran's observations on reduction of human error—provide feedback from the work performed and design work to demand attention.[32]

A more commonly used approach to detecting error is multiple inspection, often performed by a passive visual check of a list of results. For example, the interpretation of one technologist's ABO grouping results may be visually reviewed and verified by a second person. The relatively simple checking algorithm could be more reliably performed by computer. However, for a number of reasons, including general lack of computer availability, poor design of some systems, and computer downtime, it is often performed by a second-person check. The obvious hope is that if an error gets by one person, it will be caught by another. Not only does the passive check have significant potential for distraction, multiple responsibility itself does not necessarily enhance human performance. Unless carefully configured to prevent it, in a system in which two people are responsible for the same task, neither person is truly responsible. Paradoxically, such safety procedures may provide less, rather than more assurance. In the biopharmaceutical field, as many as 30 people were observed to miss an error in a multiple check system.[33] "The human eye sees what the brain thinks it should see."[33]

Kruse et al reported a small benefit to requiring a second nurse to verify medications dispensed.[34] Following a 46-week study of 129,234 medications administered, they cited an error rate of 2.98 per 1,000 medications administered by a single nurse, statistically significantly higher than the error rate of 2.12 per 1,000 medications when administered by two nurses.[34]

To verify ABO interpretation without an appropriate computer system, an alternative is to have individuals responsible for their own work, and to provide them with the means for reliably reviewing their interpretation by looking at it in a different way. For example, after agglutination results are read and interpreted, if the test tubes are replaced in either one of two rows of a test tube rack according to the simple rule of positive tubes in the back row and negative tubes in the front row, a new and unique pattern is created for each ABO group (Fig 1).

BEDSIDE IDENTIFICATION ERRORS

A College of American Pathologists study, the 1991 Q Probes' Wristband Identification Error Reporting module, designed to survey laboratory qualities, examined the success of inpatient wristband practices and policies in 712 hospitals.[35,36] In this study, phlebotomists checked wristbands during rounds for a 4-week period, recording the results. The investigators, Renner et al, reported finding 67,289 errors among 2,463,727 patients checked. They reported a median error rate of 2.2%, with some participants having error rates of 10% or greater. They reported that the most prevalent error was absent wristbands (49.5% of errors), followed by more than one wristband with conflicting information (18.3%), wristbands containing erroneous information (8.6%), wristbands

errors that might not otherwise be detected and reported. The investigators considered transfusion of the wrong unit as a major error and poor execution or documentation as a recording error. Over a period of 15 months, 808 patients received 3,485 units. The investigators reported detecting 165 errors, 15 of them major, occurring after blood units had left the blood bank. Seven were misidentifications resulting in administration to unintended patients, constituting 0.74% of patients and 0.2% of units, whereas eight other errors occurred in four patients (0.5%), including five allogeneic units administered when autologous blood was available, and one anemic patient who received a transfusion when only a crossmatch was ordered. The remaining 150 errors included misrecordings (61), misiabeling (6), and failures to document adequately the transfusion (83). They reported that the errors did not lead to any sequelae with the exception of one misidentification that resulted in a transient, but unreported reaction.[38]

Total frequency of error at the three institutions in the Belgian study was 1.9% 2.2%, and 6.9% of units. However, many of the related to components (fresh frozen plasma) issued remotely from the blood bank, a practice not common in North America. The investigators noted that none of the seven misadministration errors was spontaneously reported, and speculated that the true error rate is many times the reported rate for reported errors.[38] However, it is important to note that this study involved patients undergoing elective surgery in which transfusion is not the dominant form of therapy; no measures, such as double identification, were in place to reduce the chance of errors; and transfusion practices were very different from those of other countries. Also absent were the quality assurance review procedures routinely used in many institutions in North America. Thus, data may not be comparable. However, the study did provide documentation that the actual error rate may be significantly higher than the reported error rate.

A consulting firm working with hospitals evaluated thousands of hospital medical records to identify "vulnerability indicators" that may be associated with events susceptible to legal action and liability claims. In various hospitals in Florida, they found that documentation of the matching of the blood unit with the patient's wristband was absent from the medical records 30% to 50% of the time.[39]

BLOOD BANK ERRORS

Shulman and Kent[40] studied the incidence of unit placement errors, that is, the placing of red blood cell units in the wrong section of the refrigerator. In a study of 96,581 units at a large institution, they found an error rate of 0.12% (112 units misplaced, 1/862), with about one third of these potentially leading to ABO-incompatible transfusions if released (an ABO mismatch error rate of 0.04% or 1/2,610). They noted that placement errors are of concern, because a crossmatch cannot always be counted on to detect ABO incompatibility[40-46] and will usually not detect Rh incompatibility because most Rh-negative patients do not have anti-D. The investigators further noted that placement errors are of great concern when uncrossmatched blood is transfused in emergency situations.[40] Their study showed the importance of frequent verification of unit placement to reduce the chance of an incompatible unit being released by mistake. They found that checking only once daily would result in a correction delay of 16 hours for 37% of erroneously placed units and a delay of up to 24 hours for 32%.[40] This study was conducted at a large institution with crowded refrigerators and a large inventory, so it may not be representative of all institutions, but it documents another source of latent error that can be reduced by a protocol of double checking.

Shulman et al also identified errors in a noncrossmatch method compared with an immediate spin crossmatch method.[46] They tested 7,124 patient specimens by immediate spin crossmatch and also by a noncrossmatch method consisting of duplicate ABO testing of the patient, repeated ABO confirmation of the donor unit, and a clerical check. They reported that two ABO incompatibilities (0.02%) were missed by the noncrossmatch method because of human error, but these were detected by the immediate spin crossmatch (and therefore fortunately were not transfused). They also reported three cases of discordant donor testing results that were inadvertently overlooked and two cases in which ABO-incompatible blood was selected from inventory (group A for a group O recipient), but the error was detected by immediate spin crossmatch. The investigators noted that these

laboratories not employing any such staff had a 4.1% error rate (95.9% accuracy). The difference was found to be statistically significant ($P = .05$). The investigators concluded that such labs would have better accuracy on patient testing as well.[51]

TRANSMISSIBLE DISEASE TESTING ERRORS

Errors can also occur in the blood bank during processing and testing. Whereas minor errors in testing and acceptance of donors with a history of unacceptable test results, most notably repeat reactive tests for human immunodeficiency virus type I (HIV-1), which are negative on supplemental testing, are well known and have been the subject of numerous voluntary recalls. We are aware of two cases in which HIV-1-reactive blood was released through error. In one case, the result in question occurred at the end of a column, near text located below, which made the reactive result less noticeable to the eye. This error was detected only because the recipient was later found to be HIV-positive with no identified risk factor other than transfusion, so it is not known whether additional testing at the time would have proved positive. This latent error has since been corrected by an automated transcription system in which results are automatically interpreted and relayed to the blood bank computer system, which prevents release of units unless all tests are negative. In the other case, a technologist missed a notation of "reactive" on a tape and recorded a nonreactive result. The error was noted shortly after the transfusion, and Western blot testing proved positive (it was later found that the donor admitted to a risk factor for HIV infection). We are also aware of several other cases in which units reactive for either syphilis or antibody to the hepatitis B core antigen were released for transfusion as a result of transcription errors at hospitals.

Given the current focus on infectious disease screening of donor units, if ABO segment retesting at the hospital does not agree with the labeled blood type, there is additional cause for concern. Although a number of technical and clerical errors may cause such a discrepancy, the possibility of a tube-switch at the time of collection must be considered. Unless positive screening test results are verified by segment testing before unit destruction, there is the risk of an infectious unit being inadvertently labeled and released to inventory. Because blood unit-labeling protocols routinely include comparison with the donor's previous blood type, errors found by the transfusion service typically reflect only those units drawn from first-time donors.[29] These usually represent only a small proportion of donor units collected. Discrepancies detected before labeling give a better estimate of the potential magnitude of the problem, but are not usually considered as significant because the system trapped them. However, the true figure should also consider potential switches that would be undetectable because they occur between donors of the same blood types (about one third of the time). This is another example of the importance of studying the caught potential error, and understanding its cause.

AUTOLOGOUS BLOOD

It is well established that autologous blood is not without risk because of the risk of error. In their commentaries on autologous transfusion in pediatric patients, DePalma and Luban warned of potential errors in the identification of the patient receiving autologous blood and in labelling the unit as well as the risk of contamination.[52] Renner et al also made mention of the risk of error in their review of autologous transfusion practices at 612 hospitals.[53] Wasman and Goodnough also acknowledged that errors in the transfusion of autologous blood could occur.[54] In the 1992 College of American Pathologists Comprehensive Transfusion Medicine Survey, Set J-C, 34 of 3,852 participating facilities (0.9%) indicated that they had issued an autologous unit of whole blood or packed red blood cells to the wrong patient within the previous year. Twenty (0.5%) indicated that the unit had actually been transfused.

Simpson et al[55] studied 175 children receiving autologous blood at an orthopedic hospital and identified 13 major human errors. These errors led to the unnecessary receipt of allogeneic blood in 8 patients (5% of the total patient population). The errors they reported include: 3 were poor communication leading to outdating when elective surgery was postponed; 3, blood expired during the patient's stay, although it was needed later; 1, allogeneic instead of autologous blood transfused because the technologist performing the crossmatching was not aware that autologous blood was available; and 1, a duplicated order resulting in a second (allogeneic) unit being transfused when one unit of autologous blood was intended. Addition-

With feedback regarding deviations from protocol and active educational efforts, adherence to identification protocols (requiring comparison of blood unit paperwork with both the blood unit label and the identification band information by two different individuals) improved gradually from 50% during a pilot study and 68% during the initial phase (the first 25 audits) to 88% during audits 26 to 50, 92% during audits 101 to 125, and nearly 100% after audit number 125.[62]

The Shulman et al study identified three causes for variance from procedures: (1) insufficient knowledge because of a deficiency in orientation or training; (2) performance deficiency caused by lack of acceptance of the procedures, indifference, or carelessness; and (3) system deficits. The first two were addressed by in-service training of staff. Whereas some nurses initially did not see the point of verifying the identity of a patient well known to them, compliance greatly improved when they were educated to understand that the check was designed to detect a blood bank error, not just to assure the identity of the patient. Adjustments to protocols were made to address system deficits in two problematic areas: the operating room and neonatal intensive care units (NICU). Alternative identification procedures were developed for use in surgical patients whose wristband had been removed or whose wristband was obscured by surgical drapes. In the NICU, placement of the wristband on an intravenous line was permitted if the infant could not wear a wristband because of treatment modalities used or deficit in skin integrity. The investigators found in-service education to be a very effective means of increasing compliance with protocol and reducing the risk of error.[62]

Taswell, during his 25-year tenure as director of the blood bank at the Mayo Clinic, made a concerted effort to study errors and devise solutions.[63] He found simple classifications such as "technical" or "clerical" to be insufficient and not conducive to prevention. He initiated a program to detect, report, analyze, and categorize all errors in his laboratory, classifying errors by site of origination: during collection and processing, in the crossmatch laboratory, or at the bedside. Additionally, he classified them by "function": identification, transcription of information, storage and retrieval, interpretation, or performance (such as technical procedures). He found an error rate of 28.3/10,000 procedures, with the highest rates in clerical areas. He felt that this error rate was very low for human functions and probably reflected his intensive efforts over the years at staff education to recognize and avoid error. His efforts to reduce the likelihood of error therefore focused on technology to correct system deficiencies, implementing computerization, and computer-generated bar code–readable labels. Within the last year, the facility also introduced automated blood grouping of bar coded–labeled specimens that feed directly into the laboratory information system. These strategies have considerably reduced the opportunities for human error.[63]

Eagle and Davies[64] and Reason[2] have pointed out, as did Berwick in his "Theory of Bad Apples,"[65] that active failures receive much more attention than passive failures, and often are at the center of attention at Morbidity and Mortality Rounds. The errant practitioner is often cast as a "bad apple." This has two undesirable effects: (1) other contributory sources of latent error go unnoticed and unrectified; and (2) practitioners may become fearful, defensive, and uncooperative, trying to hide problems rather than address them. They conclude that remedial action must be directed at latent as well as active errors to be effective.[64]

Bar codes used for identification in many blood centers serve as one system remedy to address latent error. After a bar code label is applied to the pilot tubes and bag by the phlebotomist, identification is ensured by machine reading during the testing process, to eliminate the possibility of transcription errors in identification, and during the labeling process. Computerized testing equipment can transfer test results electronically to the central blood bank computer, eliminating the possibility of transcription errors. The computer can also prevent labeling of a unit unless all tests have been performed with satisfactory results. Hand-held phlebotomy bar code devices have recently become available on the market. The devices allow the phlebotomist to scan the wristband and the specimen collection label for positive patient identification. The date and time of collection and the phlebotomist's identification can also be recorded automatically. The information can then be uploaded to the laboratory information system.[66-68] Portable bar code scanners and label printers are also available to match patients' wristbands with blood units automatically.[69] The American Association of Blood Banks has proposed revising its

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